DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

WORKING PAPER

MICRO-COMPUTER EX ANTE SMALL FARM

AGRICULTURAL RESEARCH BENEFIT/COST ANALYSIS:

ZIMBABWE, ZAMBIA AND TANZANIA

by

J MacMillan, G Mudimu, L Rugube and E. Guveya

Working Paper AEE 3/91

DEPARTMENT OF AGRICULTURAL ECONOMICS & EXTENSION
FACULTY OF AGRICULTURE, UNIVERSITY OF ZIMBABWE
P.O. BOX MP 167, MOUNT PLEASANT, HARARE
ZIMBABWE

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by

J. MACMILLAN[1], G. MUDIMU[2], L. RUGUBE[3] AND E. GUVEYA[4]

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Department of Agricultural Economics and Extension
Faculty of Agriculture
University of Zimbabwe
P O Box MP167
Mount Pleasant
Harare
ZIMBABWE

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1. J. MacMillan is a Visiting Professor in the Department of Agricultural Economics and Extension, University of Zimbabwe

2. G. Mudimu is a Senior Lecturer in the Department of Agricultural Economics and Extension, University of Zimbabwe.

3. Mr L Rugube is a Lecturer in the Department of Agricultural Economics and Extension, University of Zimbabwe

4. Mr E. Guveya is a Research Assistant in the Department of Agricultural Economics and Extension, University of Zimbabwe.

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1. INTRODUCTION

The general purpose of the working paper is to provide a group of case studies to be used in agricultural research management workshops with the working paper, Agricultural Research Management Training Needs in SADCC[2]. The paper on training needs recommends the application of ex ante benefit/cost analysis as a planning and control tool for improving the productivity of SADCC agricultural research projects. Ex ante B/C evaluation refers to economic analysis of research project benefits versus costs for a range of alternatives prior to initiation of a project. Ex post B/C evaluation refers to the economic analysis of benefits versus costs after completion of a research project. Historical assessments of projects in Ex post evaluations are useful but not directly relevant for investment decisions on current and proposed projects.

The project research underlying the case studies is considered to be illustrative of the potential for applying ex ante benefit/cost analysis to agricultural research involving investments in plant breeding, as well as extension activities. High priority agricultural research problem areas as identified in the research management needs assessment are emphasized in the case studies. Plant breeding, farm financial returns with and without subsidies, policy analysis of alternative export/import parity pricing scenarios and domestic Resource Cost calculations. Micro-computer software is used in the analysis because of the powerful capability of the micro-computer to analyse alternative scenarios for large series of financial data in a standard format[3]. Minimal economic or micro-computer spreadsheet knowledge is required to complete the case studies. The objective is to structure the material in a self-explanatory format with required economic and software terms defined in the text and Appendixes. Answers to case study assignments are given in Appendix B.

The specific objectives of this paper are:

1. To illustrate the calculation and interpretation of basic capital investment criteria: internal rate of return, net present value, payback, and benefit/cost criteria;
2. To illustrate the application of benefit/cost analysis to investment in Zimbabwe communal small farm maize research and demonstration activities in a farm and village context;
3. To illustrate the application of benefit/cost analysis in evaluating the Zambia-Canada wheat breeding project; benefits to small farmers include: "farm financial" analysis, economic analysis and export/import parity pricing. In addition, the number of small farm wheat producers required to generate a positive beneifit/cost ratio is calculated; and
4. To illustrate the importance and measurement of foreign exchange impacts and

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[2]See MacMillan J., G. Mudimu, L. Rugube and E. Guveya, Agricultural Research Management Training Needs in SADCC, Draft Working Paper, Department of Agricultural Economics and Extension, Harare, June, 1991.

[3]Lotus 1-2-3 and Quattro Pro spreadsheets have identical financial functions as outlined in the case studies. Excel spreadsheets can also be used but different functions are required.

Domestic Resource Cost calculations (DRC) in assessing the economics of production of small versus large farm rainfed wheat production in Tanzania. In addition, effects of market location and unsubsidized foreign exchange input costs on project investment criteria are reviewed.

The format of each case study is similar. Objectives are indicated followed by a review of required concepts and definitions. Application of the concepts is assigned at the end of each case to demonstrate an understanding of the significance and procedures for calculations. In addition it is suggested that workshop participants be requested on an individual group basis to make presentations on one or more of the case studies evaluating the following: 1) the problem addressed, 2) research objectives, 3) alternative courses of action, 4) recommended action including appropriate organizational structure, 5) a proposed budget including staff costs for the recommended action and 6) an assessment of the expected benefits versus costs for the proposed action.

2. CAPITAL INVESTMENT ANALYSIS

2.1 Objectives

This exercise makes use of Lotus 1-2-3[4] which provides functions and format for internal rate of return, net present value, and payback calculations as well as interpretations. A secondary objective is to illustrate the use of the personal computer in research management.

A capital purchase involves a project investment cost to-day which is expected to generate a surplus of annual receipts over operating costs in future periods. From either a private or public sector perspective capital investment represents a use of funds which should be compared with the potential returns possible from a savings account. In this situation the principal and interest earned could be invested at a later date. If an investment cannot earn a future stream of income greater than the potential savings account earnings at the best interest rate available then the investment should not be made.

For example agricultural research considered as an investment should provide a return greater than the principal plus interest possible in a bank savings account. If a positive investment return is not possible then research funds could be put in the bank and interest earnings paid to farmers and other expected beneficiaries. Farmers would be better off in this case with the bank interest earnings and without the research.

Capital investment decisions lead to long-term commitments which may be impossible to

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[4]The basic format of the exercise is taken from E Gardener, "Making Capital Investments", Lotus 1-2-3, May 1987, p57.

reverse. Annual cash flow estimates (measuring annually the sum of project capital investment costs, plus annual operating receipts less annual operating costs) are the most difficult part of the analysis. The investment analysis ignores accounting interest expenses and depreciation. Interest is covered in the discounting process and depreciation is not relevant because the investment decision is made at time zero and salvage value is considered to be zero for the cases analyzed.

In this exercise, two investment projects are compared. Project A has an initial investment cost of $100,000 and Project B has an initial cost of $150,000 (see Table 1). The investment costs are entered in the cash flow stream as a negative value at time zero. Project A returns the net receipts stream of 35, 45, 55, 60, and 60 for years 1-5. Net receipts are the result of subtracting annual operating expenses from annual operating receipts.

2.2 Payback

The Payback period is the number of years required to payback the original amount invested. The time value of money is ignored in the payback criterion which is defined by the number of time periods (years) required for the cumulative undiscounted sum of annual cash flows to become positive.

2.3 Discounting and Compounding

The discount rate is equivalent to the minimum rate of interest that a an investor requires for new investment projects, or the cost of capital reflecting the cost of funds. Discounting is required because the value of money, measured against to-day when the investment decision is made, declines over time. The discount rate is itself a price paid by public or private investors to lenders for the use of their savings[1]. At any point in time the observable money interest rate, m is the sum of a "real" interest rate, r and anticipated inflation, a:

$$m = r + a.$$

Economists vary in their estimates of the average long term real interest rate from 3-7 percent. Depending on the point in the business cycle real interest rates can be positive or negative when estimated by subtracting the inflation rate from the interest rate on "risk-free" debt. In stable economies the rate of interest paid on government bonds may approximate the risk free cost of capital. For example, with a government bond rate of 14 percent in a country with a stable economy and inflation of 7 percent, the estimated real rate of interest is 7 percent.

1See Randall, A., Resource Economics, 2nd ed, John Wiley & Son, 1987, p238-40.

Compound interest occurs when one dollar is put in a savings account to-day earning 10% interest. The principal and interest will equal $1\$(1 + .1)^1 = \$1.10$ one year from to-day. Reversing the situation $1 received one year from now is worth $\$1/(1 + .10) = \$.909$. Discounting the cash flow items for Project A (years 1-5 in Table 1) results in the following present values:

$$\frac{35}{(1.2)^1} = 29, \quad \frac{45}{(1.2)^2} = 31, \quad \frac{55}{(1.2)^3} = 32, \quad \frac{60}{(1.2)^4} = 29,$$

and $$\frac{60}{(1.2)^5} = 24$$

The present value of project A's annual cash flow earnings for years 1-5 is $145,290. The present value factor is equal to $\frac{1}{(1+r)^t}$ where r is the discount rate and t is the number of years from the start-up of project.

2.4 Definitions

The project benefit B, is defined as the present value of the cash flow Years 1-5, i.e.,

$$B = \frac{(\text{Receipts - Expenses})\ t}{(1+r)\ t}$$

The project cost,C, is defined as the present value of the investment outlays:

$$C = \frac{(\text{Investment Cost})t}{(1+r)^t}, \text{ or}$$

$$= \text{Initial Cost} - \frac{\text{Salvage Value}}{(1+r)^t}$$

In tis case salvage value is assumd to be zero.

The alternative criteria can now be summarized as follows:

1. Payback is equal to the number of years required for undiscounted B to equal C.
2. Net present value is equal to B-C.
3. Benefit/cost ratio is B/C.
4. IRR is the discount rate, r, for which B-C = 0

2.5 Net Present Value

Net present value is the difference between the present worth and present cost of a project. If the present value of the cash flow for years 1-5, $145,290 is deposited at 20 percent annual rate of interest and the cash flows are withdrawn annually, the fifth

withdrawal empties the account. If the total present value of the project is greater than or equal to the investment cost, the project is attractive. 145 - 100 = $45.

2.6 Benefit/Cost Ratio

The present value of the stream of annual net receipts, B, is divided by the investment cost, C, (145/100 = 1.45).

2.7 Internal Rate of Return

Technically, the internal rate of return (IRR) is the discount rate at which the present worth of a project's net receipts generated in the future is just equal to the present value of the project cost. The IRR can be viewed as the interest rate that a banker will pay an individual for an initial deposit of $100,000 under Project A followed by a withdrawal of $35,000 at the end of Year 1, Year 2, $45,000 ...and Year 5, $60,000. The withdrawal each year is made after interest is compounded. The withdrawal at the end of Year 5 empties the account.

If the IRR exceeds the cost of funds, then the project is viewed as being favourable with respect to the IRR criterion. If there are positive and negative cash flows during the life of the project, the IRR can give more than one answer.

2.8 Microcomputer Assignment

The spreadsheet[2] created by the instructions in Table 2 is given in Table 1 using a 20 percent discount rate.

1. Using a 10 percent discount rate, calculate net present value (NPV), payback, IRR and B/C.
2. Using the 10 percent discount rate, select A or B giving reasons.

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[2]The spreadsheet requires the use of the following lotus functions: @NPV, @Look-up, @IRR. See Appendix A for definitions.

TABLE 1

CAPITAL INVESTMENT ANALYSIS

Project A			Project B		
Cash Flow	Sum	Year	Cash Flow	Sum	Year
($100)	($100)	0	($150)	($150)	0
$35	($65)	1	$60	($90)	1
$45	($20)	2	$65	($25)	2
$55	$35	3	$70	$45	3
$60	$95	4	$75	$120	4
$60	$155	5	$75	$195	5
Discount Rate		20%	20%		
IRR		37%	34%		
NPV		$45.29	$51.96		
Payback Periods		3	3		
Benefit/Cost		1.45	1.35		

*Cash Flow = Annual sum of project cost + Annual Operating Receipts minus Annual Operating Expenses

Table 2
Lotus 1-2-3 Functions and Format for Capital Investment Template

B2: 'IRR, NPV and Payback
B3: 'Capital Investment Calculator
A5: 'Project A
D5: 'Project B
A7: "Cash
D7: "Cash
A8: "Flow
D8: "Flow
B8: "Sum
C8: "Year
E8: "Sum
F8: "Year
A10: -100
B10: @SUM(A$10..A10)
C10: 0
D10: -150
E10: 0
F10: 0
A11: 35
B11: @SUM(A$10..A11)
C11: 1
D11: 60
E11: @SUM(D$10..D11)
F11: 1
A12: 45
B12: @SUM(A$10..A12)
C12: 2
D12: 65
E12: @SUM(D$10..D12)
F12: 2
A13: 55
B13: @SUM(A$10..A13)
C13: 3
D13: 70
A14: 60
C14: 4
B14: @SUM(A$10..A14)
D14: 75
E14: @SUM(D$10..D14)
F14: 4
A15: 60
C15: 5
D15: 75
E15: @SUM(A$10..D15)
F15: 5
A17: 'Discount Rate
C17: *(P2) 0.2
F17: (P2) 0.2
A19: 'IRR
C19: (P2)@IRR(C17,A10..A15)*
F19: (P2)@IRR(F17,D10..D15)
A20: 'NPV
C20: (C2) +A10+@NPV(C17,A11..A15)**
F20: (C2) +D10+@NPV(F17,D11..D15)
A21: 'Payback Periods
C21: @VLOOKUP(0.01,B10..C15, 1)+1
F21: @VLOOKUP(0.01,E10..F15, 1)+1
A22: 'Benefit/Cost
C22: (F2) @NPV(C17,A11..A15)/-A10***
F22: (F2) @NPV(F17, D11..D15)/-D10

( ) do not type bracket encl at beginning instead:
use:
*(P2) format the cell for percent with 2 decimal places
**(C2)use currency ($) format for cell
***(F2)use number format to give 2 decimal places

3. ART FARM AND AGRITEX SMALL FARM MAIZE RESEARCH/DEMONSTRATION: ZIMBABWE

3.1 Objectives

The first objective is to demonstrate superior yields achievable with high yielding white maize varieties available from commercial seed distributors under local community conditions. Adoption in terms of hectares switched to higher yielding varieties by communal farmers caused by the ART Farm and AGRITEX research and demonstration activities is expected to generate a satisfactory return per dollar invested in the activities. The research and demonstration activities are considered as an incremental investment activity after investments in plant breeding research by the Zimbabwe Seed Coop and other commercial seed companies.

Illustrative B/C analysis indicates that a very small percentage of farmers need to switch to higher yielding varieties as a result of the research and demonstration activities by ART Farm and AGRITEX to generate a positive B/C ratio. The illustrative analysis assumes that five years after the first trial 50 out of an estimated 1000 maize hectares are switched to new higher yielding hybrids as a result of the trials. The estimate of 1000 maize hectares under the influence of a single village extension worker is based on the assumption of an average 1.25 hectares per household with an average of 100 households in 8 villages. It is assumed that the yield increase associated with the new hybrid is 1 t/ha.

The majority of communal farmers grow hybrids R215 and R201 and have not switched to higher yielding varieties recommended by seed companies because of the lack of information on the new varieties. When the Seed Coop was the only producer of new varieties the screening information was all provided by one agency. With several companies producing competing varieties the communal farmers do not have any objective basis for selecting one hybrid over another based on their farm management practices and local community condidtions.

The project is being co-ordinated with the Chief Agricultural Extension Officer for Mount Darwin District, Francis Mashayamombe. ART Farm research co-ordinator, Langton Mutemeri and Village Extension Worker, Matthias Chinhema each made about 6 visits to the demonstration trial throughout the project: prior to planting, planting, two through growing season, harvest and presentation of yield results. Ten hybrid varieties were selected for the research/demonstration and planted in a 40 by 20 meter plot:

1) SR 52-full season 160 days to maturity, expected yield of 2-8t/ha is indicated by the Seed Coop,
2) SC 601-a popular new variety, expected yield ranges from 3-13 t/ha (low management,3-4, middle management, 4-8 and high management, 8-13 t/ha),
3) SC 501-expected problems with leaf blight and cob rot with late rains and unstable yields, to be replaced with SC 601 by the Seed Coop, expected yield ranges from 2-8 /ha, and 2-4 t/ha in communal areas,
4) R 215 -medium maturity hybrid in production since 1980, expect yields from 1-5 t/ha,
5) R 201-short season 90 to 100 days, expected yields range from 1-5 t/ha

6) PNR 695-medium maturity,
7) PNR 6549-long maturity of 145 days,
8) PNR 473-136 days to maturity,
9) CG 4539 and
10) CG 4585

The trial was fertilized at recommended levels and planted in early December.

A second objective is to extend activities to be considered to include maize, soyabean, groundnut and sunflower cultivars, as well as consider alternative agronomic practices including fertilizer levels, time of planting and spacing and conservation tillage.

3.2 Community Description

The trial land is located in Natural Region IIa and IIb which is suitable for intensive farming with expected rainfall ranging from 750-1000 mm of rainfall per year. Kandeya Tribal Trust land is organized into 16 wards with 6 villages of about 100 communal farm households per village. Assuming an average household size of 11 there is an estimated total of about 6,600 people per ward. Wards have hereditary chiefs. Each village may have kraal heads which are hereditary positions and a village chairman which is an elected political position. Land is allocated to farm households by the chiefs and kraal heads who have larger than average land holdings. Land is not as limiting a factor of production as the constraint of funds to purchase fertilizer and other inputs.

Agritex estimates 21,000 ha of maize production in Kandeya for 1991. The village is 15 km from Mt. Darwin the site of a Grain Marketing Depot. Fertilizer and seed are delivered to the community. Farmers are very interested in cash crops: cotton, tobacco, sunflowers and soyabeans.

3.3 Adoption

The adoption process is expected to proceed first from the farmers interacting with the extension officer in the 8 village extension area which includes the research and demonstration variety trials It is then expected that adoption would spread to about 10 other maize producing wards in Kandeya. Agritex officials suggested that the adoption process might proceed with 15% of farmers in the ward switching after 2 years of successful demonstrations. It was suggested that 75% might switch after 3 years successful data and 90% after 5 years. The AGRITEX Village Extension Worker works with village "groups" to promote advanced farming methods including variety selection.

Baseline data is required to measure the hectares of maize, varieties, yields and agronomic practices for the maize harvested in 1991. Follow-up monitoring of the adoption process is required over a five year period to measure actual changes caused by the ART Farm and AGRITEX research and demonstration activities relative to forecast changes from the baseline situation. In terms of an "experiment" the value of the maize crop needs to be estimated with-versus-without

the research/demonstration activities. Ten communal farmers were present at the harvesting of the maize and can be expected to be "early adopters" as well as other farmers "participating" in the research/demonstration activities.
It is essential to obtain sufficient information to separate out the individual net yield effects of differences in production practices among farmers. Important differences include: variety, time of planting, field operations, fertilizer levels and time of application, spacing, chemical application, conservation practices. Quality and amount of manure is important but is very difficult to quantify. With sufficient responses from participating communal farmers regression analysis can be used to measure the net effects variations in production practices on yield. Regression coefficients can then be used to estimate the net effect of changing variety on yield separate from changes in other production practices. Regression coefficients can then be used to estimate alternative benefit/cost scenarios for alternative research and demonstration activities.

3.4 Estimation of Impacts of Cultural Practices on Maize Yield

Estimates of impacts of cultural practices on maize yield are required for estimating the benefits versus costs for the research/demonstration activities for the ward selected in Kandeya communal area. A questionnaire was designed to obtain baseline data on maize production in 8 villages in the Kandeya communal lands. Data was collected for the production of maize from farmers selected by the Village Extension Worker to give "representative" village baseline data on yields, varieties and agronomic practices. Statistical estimates for the total farm population could be based on household lists expected to be available from the 1992 Zimbabwe census. The yield and cultural practice information will be combined with price and cost information to estimate the potential net income benefits associated with research/demonstration activities on the adoption of new hybrid maize varieties. The 8 villages, each with about 100 farmers are considered to be reasonably similar with respect to soil capability and climate. Yields per acre are expected to range from 1-5 tonnes per acre.

Considerable information is available from agronomy and crop breeding research trials conducted on other communal farms in Zimbabwe with respect to fertilizer levels, date of planting and conservation practices[3]. Based on a review of research institute results for communal farm trials and discussions with farm and extension workers we expect: Maize yield/acre will be affected by variety, seeding date, fertilizer (basal, top dressing, manure), cultivation of seed bed and weeding (hand, oxen, tractor), chemicals excluding fertilizer, and conservation practices.

For the 1990/91 production year crop (planting occurs in November and harvesting in May) prices are fixed by the government in April. Given, similarity in production capability a cross section estimation of the function indicated above in physical units will provide technical production relations which are not affected by annual price variations. An estimate of the farm and village

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[3]See Agronomy Institute, Annual Report 1984/85, and Crop Breeding Institute, Annual Report 1983/84, Zimbabwe Ministry of Lands, Agriculture and Rural Resettlemen., and Farming Systems Research Unit, U of Zimbabwe, Annual Report, 1983/84.

maize income can be estimated before the research/demonstration activities and alternative ex ante benefit/cost scenarios estimated for future periods.

Over time product and input price variation will affect the farming practices. For example, fertilizer prices are expected to rise 40 percent for 1991/92 crop and it will be essential to separate out the effect of fertilizer price increases on yield for 1991/2. Maize and other relative product prices changes especially cotton, tobacco and oilseeds will also affect the level of net benefits associated with the maize research/demonstration activities. The benefit/cost model using single year gross margins (See Table 3) will have to be expanded to include product and input price variability.

Most benefit/cost analyses of agricultural research use complex economic surplus calculations[4]. Simplifying assumptions can be made which result in estimating farm financial benefits associated with research and demonstration activities as a function of the gross margin per acre and number of acres with the new variety production. Increments in gross margins per acre relative to gross margins for the old varieties are estimated for the forecast number of farms adopting new varieties as a result of the research demonstration activities (See steps 1-3 in Table 3). The adoption path and present values are calculated in steps 4 and 5. Steps 6 - 9 illustrate present value, payback, net present value, and internal rate of return calculations. Sensitivity analysis is summarized in step 10 and analysis of market decontrol reviewed in step 11.

Policy analysis scenarios for market decontrol (step 11) can be based on a horizontal demand curve for maize fixed at the government controlled price for maize. ART farm and AGRITEX are interested in improving farm financial income levels associated with maize production. As a result the farm financial estimate of the increment in gross margin associated with adoption of a higher yielding variety by farmers is the appropriate benefit measure. The conventional consumer and producer surplus calculations are not appropriate.

A complete analysis of market decontrol would include impacts of "export parity" pricing of maize to farmers. Export parity pricing of maize could result in approximately double the current government controlled maize price. The price increase to farmers would result in large positive supply response by farmers. The maize available for export would increase substantially and additional maize export earnings could be used to finance distribution of maize surpluses

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[4]See Echeverria, R.G., G. Ferreira, and M. Dabezies, Return to Investments in the Generation and Transfer of Rice Technology in Uruguay, ISNAR, Working Paper No. 30, p9. Economic surplus calculations require the estimation of economic returns using shadow pricing of inputs, removal of transfers and use of export/import parity pricing which is very complex and not directly relevant to farm production decisions. In addition, assumptions concerning the shape of supply and demand curves as well as the form of the technology generated supply shift are required. As Echeverria et. al. indicate, the analysis can be simplified if a horizontal demand and vertical supply function with a parallel supply shift are assumed.

to deficit maize production regions in Zimbabwe.

The major beneficiaries of the low maize price paid to farmers are the consumers of maize meal. Economists conclude that economic efficiency would be increased if maize producers were paid on the basis of the maize export price and consumers of maize meal subsidized. The current situation appears to result in a large "tax" on maize producers. The effect of import parity pricing versus government controlled pricing in Zambia is illustrated in the following case. Import parity pricing is used where local production substitutes for imports.

3.5 Micro-computer Assignment

1. List three of the most important difficulties in generating a positive Benefit/cost ratio and calculate what you feel is the "worst case" scenario benefit/cost ratio

2. List three areas with the greatest potential for increasing the benefit/cost ratio and calculate what is the "best case" scenario benefit/cost ratio

Table 3. Illustrative Benefit/Cost Analysis, ART Farm and AGRITEX Communal Maize Cultivator Selection Research/Demonstration

1. Estimate potential benefits based on 1990/91 yield data

Area	Farm Gate Maize Price $per t	Incremental Yield t per ha	Revenue $ per ha	Variable Cost:chem cult, labour $ per ha	Gross Margin Seed fert . $ per ha 90/91
1	270	1	270	20	250

NOTE: It is assumed the only incremental variable cost for the new High Yielding Variety (HYV) is an extra $20 per hectare. Adjustments for fertlizer and other expenses may be required.

2. Estimate adoption in terms of ha in HYV per year

Communal hectares to be planted with HYV

Area	91/92	92/93	93/94	94/95	95/96
1	1	5	10	25	50

NOTE: It is assumed that ART farm speeds the rate of adoption causing 4 farmers to switch .25 ha each to HYV in 1991/92 increasing to 50 ha in 1995/96

3. Estimate Art Farm and Agritex costs per community

ART Farm

AGRITEX

Communal Research Demonstration Costs

Area

	1990/91	1991/92	1992/93
1	4000	4000	4000

NOTE: It is assumed $2000 staff and $2000 travel per community per year made up of 6 visits requiring 1 week staff time and $500 travel cost

4. Calculate the five year time path of benefits, 1991/92 to 1995/96 for each of the five communities

Year	Incremental Rev/ha/yr	HYV hectares	Total Benefits/yr
1	0	0	0
2	250	1	250
3	250	5	1250

4	250	10	2500
5	250	25	6250
6	250	50	12500

NOTE: It is assumed that the 1990/91 gross margin is constant

5. Compare present value of benefits versus costs assuming a constant real 11 percent cost of money. Detailed present value calculations are given in step 6.

Present value of BENEFITS = 13,156 COSTS = 9,775

Benefit/Cost Ratio: 1.35

NOTE: Refinements in assumptions can be made
see step 6. below

6. Present Value Calculations
Compound interest: money in the bank earns 11%
Value of $1 at end of one year is equals:
$1(1 + .11)^1, for two years: $1(1 + .11)^2
Present Value: Value now of $1 received in 1 year
1/(1+0.11)=$0.9; Value now of $1 received in 2 yr
1/(1 + .11)^2 = $1/1.232 or $.813

	Present Value of Benefits		Cumulative Undiscounted Benefits
2	250/(1.11)^2 =	203	250
3	1250/(1.11)^3=	914	1,500
4	2500/(1.11)^4=	1,647	4,000
5	6250/(1.11)^5=	3,709	10,250
6	12500/(1.11)^6=	6,683	22,750
		13,156	

	Present Value of Costs		
1	4000/(1.11)^1	=	3,604
2	4000/(1.11)^2	=	3,246
3	4000/(1.11)^3	=	2,925
			9,775

7. Payback: In six years the cumulative undiscounted benefits will be equal to the undiscounted total costs of $12,000

8. Net Present Value: PV of Benefits less PV of Costs
Net Present Value: 13,156 - 9,775 = 3,381

9. Internal Rate of Return(IRR): Rate of interest for which PV Benefits equals the PV of Costs. Calculate the IRR from the Annual Net Cash Flow with an initial guess and recalculating until PV of B equals PV of C. IRR= 21.63%

Year	Benefits	Costs	Annual Net Cash Flow
1	0	4,000	(4,000)
2	250	4,000	(3,750)
3	1,250	4,000	(2,750)
4	2,500		2,500
5	6,250		6,250
6	12,500		12,500

10. Sensitivity Analysis:

-Use sensitivity analysis to find ways of increasing the B/C ratio and alternative assumptions

A. Increase B/C ratio by increasing rate of adoption-

Year	Total HYV hectares	Incremental Rev/ha/yr	Total Benefits/yr	
1	0	0	0	New PV of B = 16,865
2	1	250	250	
3	5	250	1250	New B/C = 1.73
4	10	250	2500	
5	50	250	12500	
6	50	250	12500	

-Increasing product prices, or yields and reducing expenses will increase B/C

B. A 11% real interest rate with inflation of 18% implies a market rate of 29%; a 6% real rate with inflation of 18% implies a market rate of 24% See step 6 above. Using 6% interest in step 5. changes B/C ratio

Present value of BENEFITS:	COSTS:
16,735	10,692
Benefit/Cost Ratio:	1.57

11. Effect of Market Decontrol on B/C calculations

Farmers expect they will be worse off with decontrol of maize product and input prices because they expect fertilizer prices to increase substantially and reduce net revenue. Analysis of market decontrol scenario impacts on B/C ratios would be useful. Estimates of export prices for maize and cotton are more than double the Zimbabwe dollar equivalent of current prices using official exchange rates.

4. WHEAT BREEDING PROJECT BENEFIT/COST COST: ZAMBIA

4.1 Objectives

The objective of this case study is to illustrate the use of financial and economic perspectives, as well as export parity pricing in the analysis of the benefits versus costs of the Zambia-Canada wheat breeding project. In addition the calculation of the required number of small farmers growing the new wheat variety to generate a positive benefit/cost ratio is illustrated.

4.2 Project Description

Foreign aid was spent by Canada on wheat breeding research in Zambia with the objective of achieving economic production of rainfed wheat to assist in achieving self-sufficiency in food production[5]. About ten million (U.S. dollars) was spent in 1986-90 in equal annual amounts over five years on: breeding research, soil studies, cropping practices and training. Training is completed in graduate studies in Canadian and other foreign universities. The project is a continuation of prior wheat breeding research. The normal time required for introduction of a commercial variety from the initial cross is about eight years, five years in trials followed by commercial testing. Varieties in the final and commercial trial stage indicate substantial potential for increasing yields. The case study is considered as being conducted in 1987 as part of a review of the project.

4.3 Micro-Computer Assignment

It is assumed that ongoing wheat breeding yield maintenance expenditures are zero for projection purposes.

You are requested to calculate benefit/cost ratios for the project starting with the information as outlined in Table 4 using the formulas given in Table 5.

You are provided with the following information. All dollar figures are in U.S. currency equivalent. The import-parity price is the international market price of grain, $170/tonne, landed in the country's major population centre and the import price is assumed constant for the projection

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[5]See Loyns, R.M.A., J.A. MacMillan, A.J. McGinnis, and J. Temba, "Report on the Mid-term Evaluation of the Zambia-Canada Wheat Development Project", Professional Services Division, CIDA, 1987.

period. The farmer's cost of grain production is $95/tonne using and estimated "shadow exchange" rate of 20:1 local currency per $1 U.S.[6]

A complete economic calculation would add subsidies to the farm cost of production. Many countries have fertilizer,[7] equipment, credit, transportation (fuel and rate) subsidies available to producers. If the local price paid for farm products by parastatals is lower than the international equivalent market export or import price then farmers are being "taxed" relative to the economic value of their product and consumers subsidized to the that they do not pay the full market value for food.

Farm Financial Perspective: The use of farm accounting costs of production and farmgate prices received from a state milling company monopoly is referred to as a "farm financial" perspective. Using the official government exchange rate of 8:1 local currency per U.S. dollar, the farmer's cost estimated by the Agricultural Department's Planning division is $238/tonne [(20/8)*95]for a 2 tonne per hectare yield, and the price paid by the Milling Company monopoly is $222/tonne. Considerable financial uncertainty is created for farmers because the grain price paid by the state milling company is not known at seeding time. The prices paid to farmers for wheat and the price of bread and flour to consumers are controlled by the government at less than international market equivalents to meet "low food cost" policy goals.

Economy-wide perspective: from an "economy" perspective, using import parity prices, farmers are producing an economic surplus of $75/tonne(170-95) but from a farm financial perspective farmers appear to be losing $16 for every tonne produced (222-238).

Several benefit/cost scenarios are estimated for planning purposes based on estimates of yield and area planted for commercial and small farmers. The table provides present value and B/C calculations for:

-Benefit (1) 1,000 ha (for the period 1986-2000) with a yield of 2t/ha; farm financial pricing is used (1,000 x 2 x -16).

-Benefit (2) import parity pricing is used (1,000 x 2 x 75).

Assignment: 1.You are requested to fill in the columns for Benefit (3)and Benefit (4) in Table 4. Benefit (3) will be the same as benefit (1)-farm financial pricing except hectares have expanded to 2,000 ha due to extension efforts and the breeders have been successful in distributing a variety with a yield of 3t/ha for the years 1993-2000. Benefit (4), same as benefit (3) except use import parity pricing.

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[6]Shadow exchange rates are based on weighted averages of import tariffs and export subsidies.

[7]In an economic context a single, government determined fixed price for fertilizer without regional differentials to account for transportation costs, represents a subsidy to isolated regions.

2. Agricultural staff are proposing that substantial benefits from additonal grain production by small farmers, each producing .25 ha of wheat, is possible with the same yield, price and cost structure. Using import parity pricing calculate the additional small farm hectares starting in 1993 to achieve a B/C ratio approximately equal to one, using the Benefit (5) column.

3. Discuss the advantages and disadvantages of using: import/export parity pricing, farm financial and economy concepts in the B/C analysis. To improve the allocation of funds by a) donor agencies and b) country planning agencies, what extensions would you suggest to make the analysis more useful?

Table 4

Benefit/Cost Case Study

($1,000)

	Costs	Benefits (1)	Benefits (2)	Benefits (3)	Benefits (4)	Benefits (5)
1986	2000	-32	150			
1987	2000	-32	150			
1988	2000	-32	150			
1989	2000	-32	150			
1990	2000	-32	150			
1991	--	-32	150			
1992	--	-32	150			
1993	--	-32	150			
1994	--	-32	150			
1995	--	-32	150			
1996	--	-32	150			
1997	--	-32	150			
1998	--	-32	150			
1999	--	-32	150			
2000	--	-32	150			
PV	7985					
B/C		-0.03	0.16			1.00

Table 5 Wheat Breeding Benefit/Cost: Lotus Functions
(see notes below before using table)

D1: 'Table 5
C3: 'Benefit/Cost Case Study
D4: '($1,000)
M3: 'No. of Farmers & Hectares
A6: _
B6: _
C6: _
D6: _
E6: _
F6: _
G6: _
C7: "Benefits
D7: "Benefits
E7: "Benefits
F7: "Benefits
G7: "Benefits
B8: "Costs
C8: ^(1)
D8: ^(2)
E8: ^(3)
F8: ^(4)
G8: ^(5)
A9: _
B9: _
C9: _
D9: _
E9: _
F9: _
G9: _
B10: \.
C10: \.
D10: \.
E10: ^dollars
F10: \.
G10: \.
A11: 1986
B11: 2000
C11 -32
D11: 150
A12: +A11+1
B12: 2000
C12: -32
D12: 150
A13: +A12+1
B13: 2000
C13: -32
D13: 150
A14: +A13+1
B14: 2000
C14: -32
D14: 150
A15: +A14+1
B15: 2000
C15: -32
D15: 150
A16: +A15+1
C16: -32
D16: 150
A17: +A16+1
C17: -32
D17: 150
A18: +A17+1
C18: -32
D18: 150
A19: +A18+1
C19: -32
D19: 150
A20: +A19+1
C20: -32
D20: 150
A21: +A20+1
C21: -32
D21: 150
A22: +A21+1
C22: -32
D22: 150
A23: +A22+1
C23: -32

D23: 150
A24: +A23+1
C24: -32
D24: 150
A25: +A24+1
C25: -32
D25: 150
A27: "Present
A28: ^Value
B28: @NPV(.08,B11..B25)
C28: @NPV(.08,C11..C25)
D28: @NPV(.08,D11..D25)

A30: ^B/C Ratio
C30: *(P2)+C28/B28
D30: *(P2)+D28/B28
A31: _
B31: _
C31: _
D31: _
E31: _
F31: _
G31: _

( ) do not type bracket encl at beginning instead use:
*(P2) format the cell for percent

5. WHEAT DEVELOPMENT PROJECT SMALL VS. LARGE SCALE FARM FOREIGN EXCHANGE IMPACTS: TANZANIA

5.1 Objectives and Project Description

Many developing countries are pursuing export and import substitution programs and have balance of payment problems. In these situations it is useful to assess the cost in domestic currency required per unit of foreign exchange earned through a proposed project. Many parastatals in Africa highlight the "foreign exchange" earnings associated with their operations. At the same time some parastatals do not indicate low or negative overall profits associated with such projects. In addition the overall level of subsidies to the parastatal are not taken into account. A means of comparing the unsubsidized domestic currency cost per unit of foreign exchange earnings is required to assess relative contributions of parastals generating foreign exchange earnings but which have low or negative profit levels. Domestic Resource Cost (DRC) calculations can be added to ex ante B/C analyses to provide important information facilating the selection of the "best" project on the basis of relative economic efficiency in generating foreign exchange earnings from either exports or import substitution.

The objectives of this case study are to: 1) summarize concepts and procedures for Domestic Resource Cost (DRC) analysis of foreign exchange impacts for small versus large scale rainfed wheat production in Tanzania[8] and 2) compare DRC results for Arusha and Dar Es Salaam markets. A large majority of farms in Tanzania use traditional tools-Jembe (hoe) and panga (machete). It is estimated that wheat production is evenly split between large scale mechanized and small scale oxen and hand tilled production. It is estimated that rainfed wheat requires at least 500mm of precipation at elevations close to 1300 metres for successful production.

The official market operates through the National Milling Corporation and Co-operatives with an open market co-existing without controls. Uniform regional or pan territorial prices and transportion rates are set annually by the government in consultation with the private sector. The delivered or CIF value of wheat imports has risen dramatically associated with the devaluation of the Tanzanian shilling. Wheat imports as a percent of domestic production have fluctuated between 50 and 70 percent in the 1980s. The majority of wheat imports have been food aid at zero dollar cost to the Tanzanian government. However, food aid represents a marginal cost if the aid could have been made available in alternative productive forms.

In comparing import substitution or export promotion projects a "large" project may generate larger absolute savings of foreign exchange. However the larger project may generate foreign exchange earnings at a very high domestic resource cost. In such a case a series of "small" projects may be a more efficient generator of foreign exchange.

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[8]The research base for this case study is taken from Frank, N.D. and R.M.A. Loyns, An Economic Analysis of Small Holder and Large Scale Mechanized Wheat Production in North Tanzania, Dept of Ag. Econ. U of Manitoba, Res. Bull. 90-1, 1991.

5.2 Economic vs. Financial Costs of Production

In project evaluation, economic analysis refers to the estimation of the impact of the project on country national income. Three steps are involved in converting farm financial analysis estimates to an economic basis: 1) removal of direct transfers, 2) adjustment for price distortions in items exported or imported, such as fertilizer and items related to transport, and 3) adjustment for price distortions in items not exported or imported, particularly land, labour and capital.[9]

5.3 Domestic Resource Cost Calculation

The definition of DRC is:

$$DRC = \text{Sum}(N_j) \,/\, \text{Sum}(E_i - M_j) \times SER$$

where:

N_j = unsubsidized domestic cost of the project in domestic currency units
E_i = exportable project outputs in domestic currency units
M_j = economic foreign exchange costs of project inputs in domestic currency units
SER = shadow exchange rate for tradeable goods

The denominator gives the net saving of foreign exchange, the value of wheat imports saved minus imports of inputs in domestic currency units. The numerator gives the domestic input costs in domestic currency units . A DRC of less than one, means that the project is an efficient generator of foreign exchange in terms of domestic resources.

Economic analysis of wheat production by small versus large farms, basis Arusha is summarized in Table 6.

The calulation of DRC basis Arusha for large farms is:
9,675.4 / (32.895 - 15,455) = .55

and the DRC for small farms is:
8,742 / (32,899 - 9,649) = .38.

Small farm production of rainfed wheat is more efficient in saving foreign exchange than large farm production. The low ratio for small farms is primarily due to the low cost of imported inputs, $9,649 for small versus $15,455 for large farms.

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[9] Gittinger, J.P., Economic Analysis of Agricultural Projects, 2nd ed., Baltimore, John Hopkins Press, 1982, pp. 250-271.

5.4 Micro-Computer Assignment

1) Calculate the DRC for large and small scale production basis Dar Es Salaam using the data in Table 6.
2) Discuss the significance of the results
3) To what extent will the results of DRC calculations for other commodities give similar results for small versus large scale production?
4) Discuss the importance of DRC calculations in developing countries without foreign exchange controls

Table 6

RESULTS OF ECONOMIC ANALYSIS FOR 1987/88 CROP YEAR
(per tonne)

	Basis Arusha		Basis Dar-es-salaam	
	Large Scale	Small	Large Scale	Small
Yield (kg/ha)	688	526	688	526
Prod Pr (Tsh/kg)	32.90	32.90	27.30	27.30
Revenue	32890	32890	27297	27297
Capital Inv	59262	19870	59262	19870
Var Costs	10347	7998	10347	7998
Fixed Costs	8108	3967	8108	3967
Tot Prod Costs	19235	12496	19235	12496
Total Costs (Prod&Dist)	25131	18392	30734	23995
Unsub Domes Costs	9675	8742	11025	10092
Econ Forex Costs	15456	9650	19708	13902
Profit	7769	14508	-3436	3303
Benefit/ Cost Ratio	1.31	1.79	.89	1.14
DRC Ratio	.55	.38		

Source: Frank and Loyns, op.cit. Table 4.2, p 46

APPENDIX A: Micro-computer functions and spreadsheet software syntax[10]

Lotus 1-2-3 Functions require the @ symbol. The function is followed by its arguments enclosed in parentheses which indicate the cells on which the function will act:

1. Sum @SUM(Range) computes the sum of a range of entries
   i.e @SUM (A1..A5) will add the values of cells 1 to 5 in column A

2. Lookup @VLOOKUP(test variable,range,column offset number)

3. Net Present Value @NPV(Discount Rate,Range) Interest rate in decimal format and the row or column of cash flows to be discounted. The interval between the cash flows must be constant (i.e. annual)

4. Internal Rate of Return @IRR(Estimate,Range)

5. Arithmetic operations in order of precedence are: ^ exponentiation, +, -, positive and negative, and *,/ multiplication and division

6. Mathematical operations require a + or - before the cell address

7. Formating instruction i.e.(%) is shown by (P2) in the function line

8. Absolute vs. relative cell addressing: relative addressing is used in copying a formula from column to column to give different addresses in the new columns, and absolute addressing is used to fix a cell location by preceding the cell address with a $ sign, eg. +$C7.

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[10] See KeBlond, G.T. and D. Hobb, Using lotus 1-2-3, 2nd ed., Que Co, 1985.

APPENDIX B: Answers to case study assignments

2.8 Microcomputer Assignment

1.Project A (10% discount rate): IRR = 37%, NPV = 88.57,
Payback = 3, B/C = 1.89
Project B (10% discount rate): IRR = 34%. NPV = 108.65,
Payback = 3, B/C = 1.7

4.3

1. Numbers are in $000.
- Benefit (1) PV -274, B/C -0.03.
- Benefit (2) PV 1284, B/C 0.16.
- Benefit(3) for the additional tonne per hectare the benefit is(-32 + 222 = 190) and for 2000 hectares (2 x 190 = 280) and PV 1108 and B/C 0.14
- Benefit (4) using import parity pricing (150 + 170 = 320) and for 2000 hectares (320 x 2 = 640). PV 2927 and B/C 0.37.

2. Using the Benefit (5) column from 1993 to 2000 use "Edit, Fill down" benefits to give B/C of benefit is 2150.
$320 represents profit from 1 additional ha. Therefore 2150/320 = 6.72 (000) hectares (includes 2000 in use prior to 1993. Therefore additional hectare 6720 - 2000 = 4720. Since 4 farmers/ha, a B/C = 1 represents 4 x 4720 = 18880 farmers.

5.4 1. Table 6 DRC for Dar Es Salaam--large 1.45 small .75